UCRL-JC-150849

Disabling Radiological Dispersal Terror

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The American Nuclear Society Winter Meeting

Technical Sessions National Meeting and Embedded Topical Meeting: Emergency Preparedness and Response
Washington, D. C.
November 19, 2002

November 8, 2002

U.S. Department of Energy

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ABSTRACT

Terror resulting from the use of a radiological dispersal device (RDD) relies upon an individual's lack of knowledge and understanding regarding its significance. Disabling this terror will depend upon realistic reviews of the current conservative radiation protection regulatory standards. It will also depend upon individuals being able to make their own informed decisions merging perceived risks with reality. Preparation in these areas will reduce the effectiveness of the RDD and may even reduce the possibility of its use.

INTRODUCTION

PERCEPTIONS:
It has been often stated and widely recognized that, in peoples' minds, perception is reality. Having spoken before public and professional audiences for nearly a decade about the subjects of radiation and radioactivity, it has become apparent that less than 1 out of 100 people will be able to distinguish between radiation, radioactive contamination, and activation. Typically, they are all viewed as the same. Combine this with a backdrop of the same people thinking that anything about radiation is harmful and consider the following two hypothetical news reports that deliberately incorporate classic slips and subtle linkages that can be found in today's literature.

OVERPLAYED NEWS REPORT #1:
Late yesterday afternoon, state police officers discovered the presence of over one ton of radioactive material in the state capital downtown district. By nightfall, federal officials from the NRC, DOE, EPA, and FEMA had been contacted. Preparations are underway to contain the approximately 2300 pounds of radioactive material to protect its spread from wind and rain while a five block radius in the surrounding area has been cordoned off for an expanded search. Because of the possible spread of radiation, traffic has been rerouted around the city using the newly constructed relief route, while state and federal emergency

teams are preparing to set up satellite command posts and decontamination centers.

Physicists working at a nearby laboratory have been contacted by telephone. They have advised state officials that the material is emitting over 14 times the amount of radiation allowed by Environmental Protection Agency safety standards for radiation in public areas. (1)

Overnight, several state agencies have brought sophisticated measuring instruments into the area and it has been determined that the radiation being given off is a highly penetrating type of gamma ray. The gamma ray energy has been measured to be over twice that given off by highly radioactive cobalt-60. Cobalt-60 is used to kill cancer cells and is reserved for use in aggressive cancer treatment. Gram amounts of cobalt-60 are typically carried in very heavily shielded, thick lead wall containers. Cobalt-60, because of its highly penetrating energetic radiation, is also used at construction sites and nuclear reactors for industrial radiography of heavy metal structures. Minute amounts of cobalt-60 have been found in several major contamination incidents around the world that necessitated the demolition and burial of affected apartments and businesses.

Recent reports are saying that scientists have been able to determine that this truck load of radioactive material, found in a local downtown park, will remain radioactive for millions of years. The governor's office has stated that they are doing everything possible to protect the public and that people who have been evacuated from surrounding residences can take shelter at the local National Guard Armory.

The White House has called for everyone's cooperation with Federal authorities in this time of crisis and asks that people understand that emergency measures may call for extreme actions. A national press conference has been scheduled for prime time on the major television networks this evening. Keep tuned to this station for up-to-date breaking news about this developing tragedy.

OVERPLAYED NEWS REPORT #2:
Reports are coming into our news center about the widespread radioactive contamination of a popular seaside resort. This scenic city of over 2000 people has been noted as a popular recreational area for high school and college age youth and is a popular location for honeymooning couples, ready to start their families. Radium, 15 times more radioactive than plutonium, has been detected over a 25 square mile area. It is unknown exactly how long the radium has been present and it is widely distributed and uncontrolled. Radium, in the form of insoluble minerals and soluble salts, has been found in local streams and rivers and is widely recognized as a strong gamma and alpha emitter. It is also known to be a bone seeker and there are numerous recorded instances where people have developed bone cancer from the alpha and gamma emissions of radium. As radium decays, it transforms into gaseous radon, which is also a strong alpha

emitter. Radon gas drifts in the air and is readily inhaled and introduced into the blood stream.

The presence of radium at this seaside resort has been determined to be pervasive in the environment. It has been found in locally grown produce and meats served to tourists in resort restaurants. Radiation fields have been measured by scientists visiting the area and have been found to be 790 times safe levels established for the public by the United States Nuclear Regulatory Commission. (2) While no current plans are in place, it can be expected that the entire population of over 2000 people will have to be evacuated and relocated to other areas. Some experts are discussing the demolition and removal of all structures followed by capping of over 25 square miles with asphalt and concrete to contain the radioactivity and protect it from water and wind erosion. They are recommending that several multi-million dollar treatment plants be constructed for capturing radium laden water run-off. This water would be treated to remove the radium salt and other radioactive elements prior to releasing the water into the sea. The extracted radium would be transported via heavily shielded metal casks to a remote radioactive material disposal site for burial.

Both of these locations actually exist. While the facts have been grossly distorted, they are based upon elements of truth. The measured radiation fields relative to regulatory standards are accurate. The surrounding conditions were deliberately overplayed to simulate how the circumstances could be blown out of proportion if one so desired. The specifics of these two locations will be revisited following a review of how radiation has been viewed historically and how these perspectives have evolved to develop today's radiation protection standards.

DISCUSSION

HISTORY:
When ionizing radiation was first discovered in 1895 its injurious effects were not immediately recognized. Within the first decade of its discovery there were indications that it could be beneficial and harmful to a person's health. (3) Radioactivity was found at many health spas with centuries old reputations for therapeutic benefits for a number of ills. (4) Pierre Curie was investigating the theraputic and harmful aspects of radiation when he placed a thinly wrapped patch containing radium on his arm for ten hours and observed his skin reacting to its presence as though it were strong chemical irritant. (5) The great inventor Thomas Alva Edison promoted the use of x-ray tubes and fluorescent screens at carnivals and fairs for people to image their bones as a novelty attraction, (6) while radioligists typically stood by their patients in the presence of intense diagnostic x-rays. (7) As these radiologists succumbed to the effects of repeated high doses of x-rays, it was recognized that radiation protection standards had to be developed. (8) The first standard was developed in the late 1920s based upon experience working with x-rays. A daily dose of x-rays, that over a year's time would redden skin, was divided by ten, halved, and rounded down to 0.1

Roentgen per day. This daily tolerance dose established a limit of 36 Roentgen per year. (9) (For practical purposes, in the explanations that follow, you will want to consider 1 Roentgen equaling 1 rem.)

This standard was used from the 1930's through World War II and the manufacture and testing of the first atomic bombs. Following World War II it was recognized that radioactive material was going to be more prevalent in society. (10) Whether it was automotive sparkplugs tipped with radioactive material for better engine performance, a child's toy ring containing glowing polonium paint, or treating your drinking water at home using uranium or radium bearing material, the general presence of radioactive material was anticipated to increase. (9) In response to these changing conditions a conservative approach was taken in reducing the radiation dose limits to 15 rem per year. This was done despite the fact that no death or injury had been documented under the 36 Roentgen protection limit. (9)

This standard was in use up to the late 1950s when naval nuclear propulsion was introduced. At a time when it was realized that sailors would be on board ships with nuclear propulsion systems for months at a time, concern developed regarding the possibility of genetic mutations occurring from the exposure to ionizing radiation. Once again, despite any evidence of harm under the 15 rem per year limit, the radiation standard was reduced to a value of 5 rem per year as a conservative approach to the question of whether there may be potential harm. The standard of 5 rem per year applies today to people working with radioactive materials.

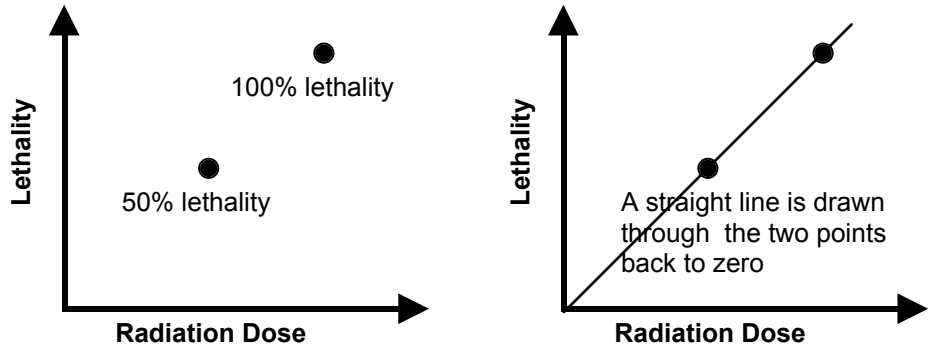
Throughout the 1950s above ground nuclear weapons testing on the part of the United States and the USSR numbered in the hundreds. (11) (12) Radioactive fallout from atmospheric testing was easily measured around the world. (13) Scientists were developing a better understanding regarding the effects of ionizing radiation on biological systems, but there was a sense at the time, that not enough was understood to quantify or even qualify the effects of radioactive fallout from above ground nuclear weapon tests on the world population. There was a concern that failure to develop standards regarding smaller doses over larger populations may not adequately address the long term impact of worldwide exposure to radioactive fallout. Some people had the sense that earth's civilization could be traveling down a regrettable path from which there would be no return.

NEW CONCEPTS:

Out of this concern came two new concepts attempting to qualify if not quantify the affect of ionizing radiation on the human body and on the human population at large. The linear hypothesis regarding the affect of radiation on humans was developed as a conservative alternative to the threshold concept. The second concept of collective dose attempted to define the affect of small amounts of radiation on large populations and was a natural extension of the linear

hypothesis. Up to this point in time, the effects of radiation were treated much like chemical toxicity has been treated. That is, a person had to receive a certain amount of radiation, a threshold amount, before it became harmful. A practical comparison to chemical toxicity is the limit to the amount of salicylic acid (Aspirin) that can be ingested before noticing a ringing or buzzing auditory sensation from tinnitus. (14)

LINEAR HYPOTHESIS (15):
A very conservative approach was used in developing the linear hypothesis. The linear hypothesis was based upon a simple assumption that any amount of radiation, no matter how small, was harmful. Essentially, it was a graph showing 100% of a population dying at a certain radiation exposure level and 50% of a population dying from a lesser exposure, with a straight line drawn through the two points and extended to zero. Figure 1.



The Linear Hypothesis Assumes That Any Amount Of Radiation is Harmful

Figure 1

THE CONCEPT OF COLLECTIVE DOSE EQUIVALENT (9):
The collective dose for a population of people multiplies the number of individuals times the dose that those individuals received. Though factors are sometimes used to adjust the final values, the concept of collective dose can be easily illustrated. In a town of 15,000 people, where everyone receives a dose of 1/3 rem per year, this would give collective dose of

collective dose = (15000 persons) x (1/3 rem / year)

collective dose = 5000 person-rems / year

If 500 rem received over a period of 24 hours was considered a lethal dose then

(5000 persons-rems / year) / (500 rem / lethal dose) =

10 people / yearly dose

Using the collective dose concept, it could be interpreted that 10 people would eventually die due to that radiation exposure over one year.

Since 1/3 rem can be considered a naturally occurring background radiation level in the environment (16) and people on the average live to 76 years (17) this would mean that out of the city's population of 15,000

(10 people / yearly dose)(76 year lifespan) = 760 people

The collective dose concept would indicate that 760 people would eventually die as the result of exposure to natural background radiation. This has not been observed. Not only has this not been observed but it has been observed that people living in an environment with less background radiation had increased mortality due to cancer when compared to a nearby population living in a higher background radiation environment. (18) (19)

The concepts of the linear hypothesis and collective dose have been used to develop today's radiation protection standards and regulations. As an example, there are two standards in particular that could be anticipated to strongly influence decisions regarding population relocation as well as decontamination and demolition of structures in the event of the use of a RDD. They are radiation protection standards established by the Environmental Protection Agency (1) (20) and the Nuclear Regulatory Commission (2).

FACTUAL REVIEW OF NEWS REPORT #1:
The approximately 2300 pounds of radioactive material can be found in downtown Santa Fe, New Mexico. It is emitting gamma radiation measured by the author, using a Ludlum Model 12S Micro R Meter, at roughly 80 to 90 microRoentgen per hour (700 to 780 millirem per year) on contact. This radioactive material is contributing a radiation field to the natural background radiation, that is in excess of the 15 millirem per year limit established by the Environmental Protection Agency for clean-up of radioactively contaminated sites prior to release for public use. The source of radiation is found in a small park setting at the intersections of Don Gaspar and Water Streets in downtown Santa Fe. People congregate around this radioactive material nearly every day. Figure 2.

The rock material appears to be of volcanic origin and is most likely the lava form of granite, rhyolite. The source of the radiation is assumed by the author to be thorium and in particular, thorium's radioactive daughter thallium-208. Thallium-208 has a 2.6 MeV gamma emission compared to 1.1 MeV and 1.3 MeV gamma for cobalt-60.

Figure 2

The Fountainhead Rock Place, at the corner of Don Gaspar and Water Streets, Downtown Santa Fe, New Mexico

This is part of the City of Santa Fe, Art In Public Places. A bronze plaque describes the park as the Fountainhead Rock Place, "Dedicated To Water, To Rock, To The Art Of Stonecraft And The Source Of Inspiration". Figure 3.

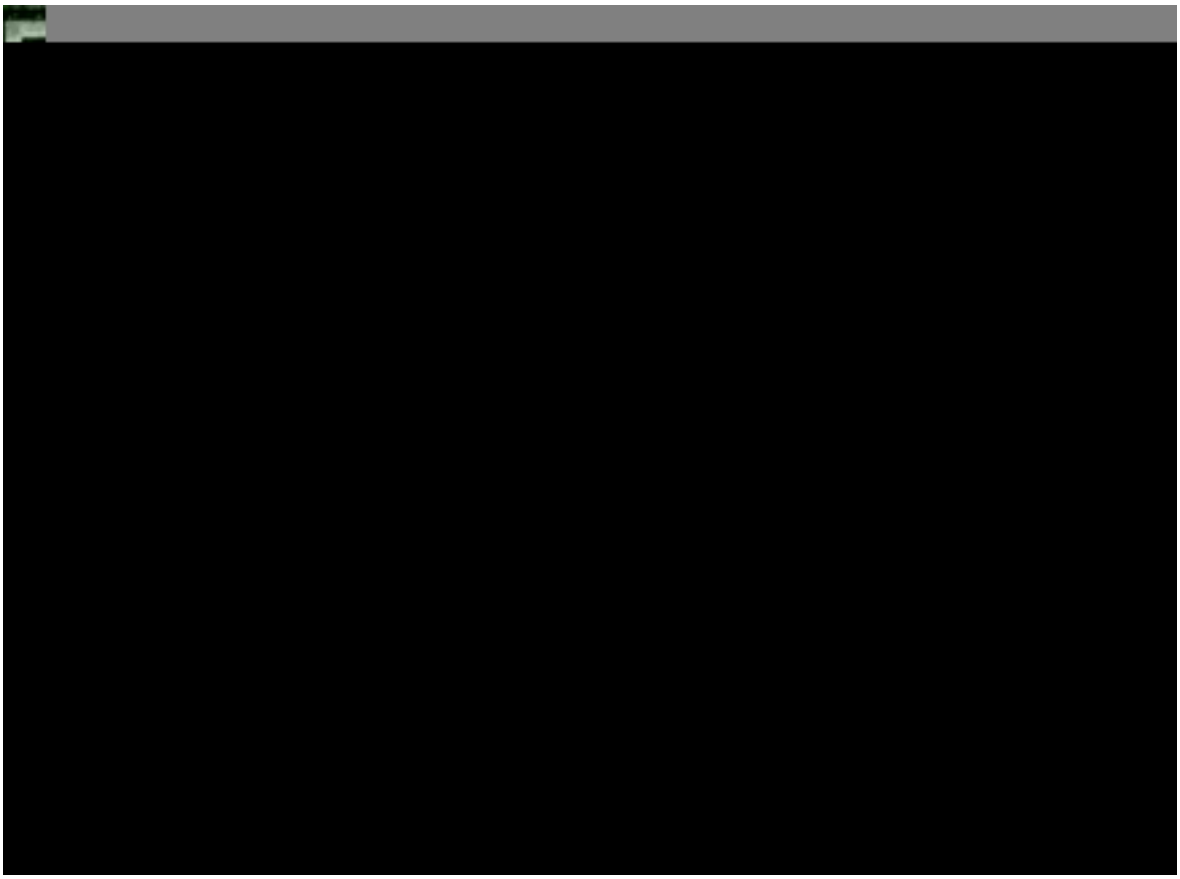


Figure 3

Bronze Plaque At the Fountainhead Rock Place Dedicated To Water, To Rock, To The Art Of Stonecraft And The Source Of Inspiration

Anyone familiar with EPA's standard would immediately state that it applies to radiation levels resulting from work using radioactive materials and that this rock and its natural radioactivity is exempt from those regulations. You would have to consider the validity of the EPA standards and limits that are supposed to be based upon protecting the public, when the radiation fields emitted from this rock would be considered inconsequential and perfectly safe in this downtown environment.

Most often, professionals do not consider themselves susceptible to issues of perception. The author has assumed that the source of the gamma radiation is naturally occurring thallium-208 within the stone. This assumption is based upon familiarity with geochemistry, mineralogy, and radiochemistry. Only a gamma meter was used to measure the radiation field. A gamma spectrometer would

have to be used to identify the particular radioactive isotope emitting the gamma rays.

Let's assume that it was decided to perform gamma spectroscopy on the Fountainhead Rock and that it showed man-made cobalt-60 rather than naturally occurring thallium-208. Someone may have laced the stone with cobalt-chloride a number of years ago or a cobalt-60 source could be hidden within. Would you call in a radiological assistance team to cordon off the area, encapsulate the stone in plastic, lift it off its pedestal with a crane, place it in a steel container on a nearby flatbed truck, and roll out of town to a desert disposal site? Or would you leave it in the park? And why?

FACTUAL REVIEW OF NEWS REPORT #2:
The seaside resort is the oasis city of Ramsar, Iran. Ramsar is situated along the Caspian Sea shore, north of the Elburz mountain range. The off shore weather patterns are very favorable for regular precipitation in an otherwise desert geography. The rain not only supports the local lush vegetation and orchards, it also recharges underground aquifers. These underground aquifers are heated by regional geothermal activity and supply the local hot springs.

On the way to the surface, hot water flows through subterranean uranium deposits. The radioactive decay within the uranium deposit is continually creating radium-226. Hot water flowing through the uranium deposits preferentially dissolves the radium, leaving the uranium behind. This dissolved radium and other minerals are brought to the surface at the hot springs. As the hot water reaches the surface and cools, the radium and other minerals precipitate out as solids and are deposited on the landscape. This process has continued over countless years. Over time, the presence of radium has built up to make the radiation fields found today in Ramsar and surrounding areas.

Despite high natural background radiation fields in the area of up to 79 Roentgen (rem) per year and the fact that gram for gram, radium-226 and plutonium-239 have comparable radiotoxicity (21) (22), the frequency of cancer and life span of people living in the Ramsar area is not notably different compared to other general populations around the world. (23) This is not surprising when considering that no death or injury had been documented under the original 36 Roentgen radiation protection limit. There are other locations around the world, including the United States, where high natural background radiation areas exist with no observable detriment to the population. These regions have radiation fields that are many times the one-tenth rem per year limit set by the Nuclear Regulatory Commission for public exposure to ionizing radiation resulting from work with radioactive materials.

THE RADIOLOGICAL DISPERSAL DEVICE:
If a radiological dispersal device were used, the affected area would be cordoned off, radioloactive material detected, contained, and cleaned up. Clean-up would employ the best detection technology and decontamination methodology available. Perfection could not be guaranteed in the clean-up of radioactive material introduced by the RDD. The question is whether regulatory agencies and the general population would be, or should, be concerned about whatever little radioactive material remains. The first answer might be that the regulatory agencies would have no choice but to be concerned because of existing statutory limits on the exposure of the public to radiation fields from man-made sources. The second answer is that since the public continues to be indoctrinated in the concept that the smallest amount of radiation can cause "genetic mutation and cancer" (24), their reaction can be anticipated to be one of completely irrational fear. Many more people can be anticipated to be injured or die from the fear and panic following the use of an RDD than from the effects of the RDD itself.

I would assert that the effectiveness of the RDD will not be defined by its explosive power, the type or quantity of radioactive isotope, area, or location of dispersal. The effectiveness of an RDD used against society and civilization will be largely defined by how it is viewed and treated by the public before and following its use. This effectiveness can be unintentionally enhanced by professionals and public officials. Under current regulatory standards, we are poised to unwittingly assist the terrorists in their work. Current EPA and NRC regulations could be used to force people to give up their personal possessions and leave their residences under circumstances involving radiation fields that are a mere fraction of radiation fields that people, around the world, live in every day without harm. (25)

The effectiveness of the terror also relies on the individual's feeling that they are not in control of their destiny and cannot protect themselves. The idea that "any amount of radiation is harmful" in the minds of the public makes them psychologically vulnerable to a radiological attack. The idea that "any amount of radiation is harmful", started as an assumption and remains an assumption. Contrary to popular impressions, it has never been proven that "any amount of radiation is harmful".

CONCLUSION

Review of regulations that could be applied in these situations should begin now rather than be considered after the use of a RDD. We will have effectively mousetrapped ourselves if we fail to re-evaluate and address potentially applicable regulations before the use of an RDD. We will either needlessly displace populations and incur tremendous costs in demolishing and replacing structures or, on an ad-hoc basis revise standards to address this new situation before the distrustful eyes of an incredulous public. A plan in work, consisting of

reviews of newly presented facts, would be a far more acceptable foundation for addressing regulatory standards in the event of the use of a RDD.

The time may come when we have to make some hard decisions that will inevitably affect peoples' lives in a profound way. You can view this in a detached manner by simply acknowledging that there will be a certain amount of disruption in peoples' lives. Alternatively, suppose a RDD was used in your neighborhood and you are told that you are to leave your residence and all of your possessions, never to return. Just how high of a radiation field, compared to what is found naturally, would convince you that this is the right thing to do? Figure 4, Figure 5. (26)

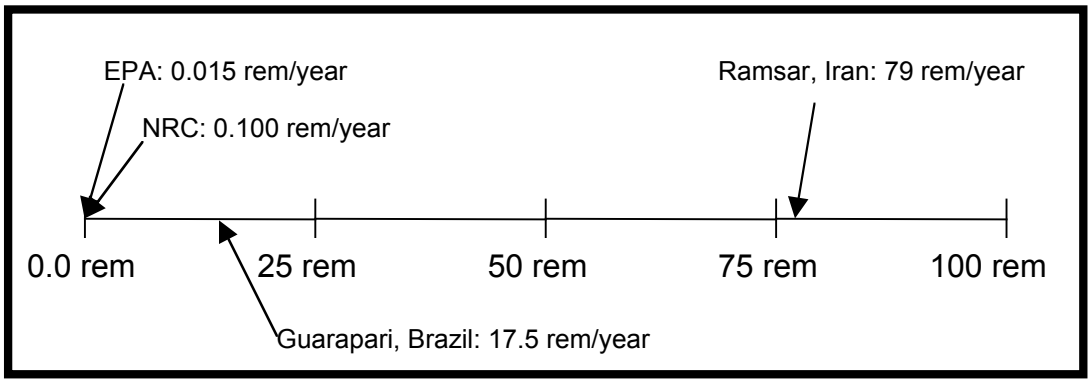


Figure 4

Scale Comparing EPA And NRC Regulatory Limits To Natural Background Radiation Environments

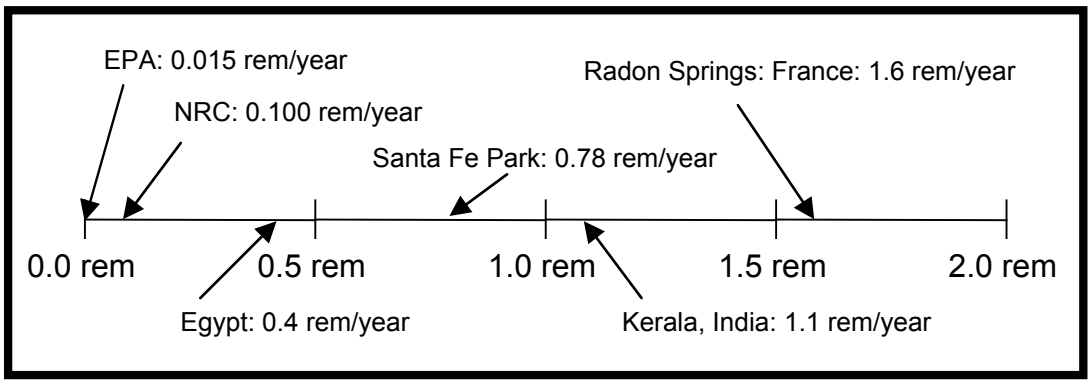


Figure 5

Expanded Scale Comparing EPA And NRC Regulatory Limits To Natural Background Radiation Environments

The ultimate effectiveness of a radiological attack rests upon three radiation protection hinge points that have developed over the past 80 years. They are the history of dose limits, the linear hypothesis, and the concept of collective dose equivalent. Their evolution has put society in a vulnerable state when dealing with the use of an RDD. The public has been indoctrinated to think that any amount of ionizing radiation is harmful. This perception must change for the public to have a more realistic perspective. Merely obtaining a basic understanding where these concepts came from, and how and why they were developed, would be a good start in dispelling inappropriate fears surrounding lower levels of radioactivity. In this way, the terrorist's ability to evoke fear in using an RDD will be greatly diminished, which could very likely rid us of the threat altogether.

This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

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